Building Information Modeling: Analyzing Noteworthy Publications of Eight Countries Using a Knowledge Content Taxonomy

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ABSTRACT

Building Information Modeling (BIM) tools and workflows have the potential to significantly improve the efficiency of design, construction and operation activities. Numerous BIM deliverables and their respective requirements have been widely discussed by industry stakeholders. This is evidenced by the intensity of online communications surrounding BIM topics and the accelerating availability of *noteworthy BIM publications* (NBP)s. NBPs are publically-available industry documents incorporating guidelines, protocols and requirements focusing on BIM deliverables and workflows. These publications are the product of various governmental bodies, industry associations, communities of practice and research institutions, intended to facilitate BIM adoption, and realize BIM's value-adding potential.

A specialized taxonomy is employed to analyze 57 noteworthy BIM publications from across eight countries selected for their active BIM scene. The *BIM knowledge content* (BKC) taxonomy includes three *knowledge content clusters* (guides, protocols and mandates) subdivided into 18 *knowledge content labels* (e.g. report, manual, and contract). Ten of these content labels are used to analyze and compare publications from Australia, Denmark, Finland, the Netherlands, Norway, Singapore, the United Kingdom, and the United States. Preliminary content analysis is then performed which provides insight into the availability and distribution of BIM knowledge within noteworthy BIM publications. The analysis identifies knowledge gaps within publications and highlights opportunities for future research and complementary publication efforts.

This chapter contributes to organizing BIM knowledge as contained within numerous noteworthy BIM publications and – by that - facilitates targeted access to their content. It provides a knowledge repository for construction industry stakeholder's to utilize during BIM implementation and a research base for investigators seeking to identify and address knowledge gaps across the BIM domain.

INTRODUCTION

The escalating coverage, connotation and impact of BIM concepts and tools have led to the proliferation of BIM-focused publications. Industry associations, governmental bodies and academic communities across several countries are increasingly developing and releasing a variety of BIM strategy

documents, BIM adoption reports, data exchange standards, and model-based collaboration protocols. These noteworthy BIM publications (NBP)s include significant knowledge and structured guidance relating to BIM implementation, project delivery and team collaboration. However, the BIM knowledge contained within these documents is rarely analyzed as a whole or labeled accurately as to reflect their true benefit and intended use. Within numerous NBPs (refer to Table 1), many terms – e.g. *BIM protocols*, *BIM guidelines* and *BIM standards* – are either used interchangeably or without qualification. The knowledge content of these NBPs is thus often masked by the documents' surrogates (e.g. titles and headings) and difficult to identify and benefit from. This ambiguity necessitates a *knowledge content identification and organization approach* that (a) shifts attention away from potentially uninformative publication titles and towards their actual knowledge deliverables, and (b) facilitates content analysis, comparison and further development.

IDENTIFYING NOTEWORTHY BIM PUBLICATIONS

Noteworthy BIM publications (NBP)s are publically-available documents developed by various academic, governmental and industry entities, aimed at a wide audience, and intended to promote BIM understanding, regulate BIM implementation or mandate BIM requirements. These publications encapsulate extensive BIM-focused knowledge, represent significant domain expertise and are a substantial effort within the BIM domain. To assist in identifying NBPs and informing the selection process, the authors employed explicit ontological structures from the BIM Framework (Succar, 2009) as represented in Figure 1.

The BIM Framework and its ontological structures are intended to organize domain knowledge and facilitate its understanding. Figure 1 explores how noteworthy BIM publications are derived from the interaction of BIM fields and BIM lenses:

- NBPs are documents (i.e. not websites, blogs or similar);
- NBPs reflect BIM knowledge (i.e. publications focused on BIM skill are excluded);
- NBPs are the deliverables of BIM players (i.e. publications delivered by players from other industries are excluded);
- NBPs cover relevant BIM topics (i.e. publications covering pre-BIM topics are excluded);
- NBPs are macroscopic (i.e. documents aimed at small groups of practitioners or students are excluded); and
- NBPs are selected and organized by country of origin (i.e. NBPs developed across several countries are excluded - e.g. Inpro-EU[1], IDDS[2] or bSI[3]).

[1] Open Information Environment for Knowledge-Based Collaborative Processes throughout the Lifecycle of a Building, please refer to http://www.inpro-project.eu/main.asp

[2] Integrated Design and Delivery Solutions, please refer to http://www.cibworld.nl/site/programme/priority_themes/integrated_design_solutions.html

[3] buildingSMART International and their varied noteworthy publications, please refer to http://www.buildingsmart.org/

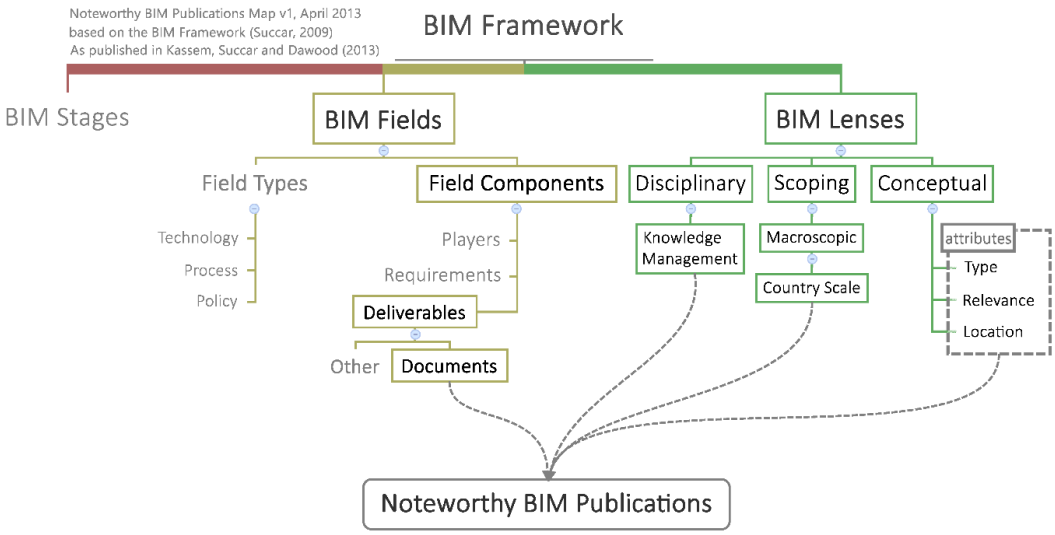

Figure 1. Conceptual derivation of Noteworthy BIM Publications using the BIM Framework

Using the framework-based delimitation, NBPs include numerous types of published documents spanning industry initiatives, peer-reviewed journals, self-published books and other noteworthy publications. However, for the purposes of targeted analysis, this chapter focuses exclusively on publications developed by governmental bodies, industry associations, research institutions and communities of practice.

The next section identifies a preliminary list of 55 NBPs from across eight countries and provides a succinct summary of their contents. These NBPs have been selected by analyzing a number of discussions conducted by/with subject matter experts (SME)s – including:

- Recommendations by industry experts identifying the relative importance of NBPs in their daily work;
- Prominence of individual NBPs in web searches when using keywords similar to "BIM guidelines USA" and "BIM standards Australia"; and
- The apparent frequency certain NBPs are referenced in online discussions similar to those conducted within specialist LinkedIn groups (e.g. BIM Experts group and BIM Consultants group).

IDENTIFYING NBPS FROM EIGHT SELECTED COUNTRIES

Using the ontological structures presented in Figure 1, Table 1 in the appendix is a non-exhaustive list of 57 noteworthy BIM publications from across eight countries selected for their active BIM scene. Table 1 introduces a preliminary list of noteworthy BIM publications, all intended by their authors to guide BIM implementation and improve workflows and deliverables across the construction lifecycle. It includes a descriptive summary of each publication's knowledge content. Identifying Table 1 as preliminary reflects the risk in inadvertently excluding equally-noteworthy publications. Additional effort will be needed to identify supporting selection metrics (Kassem, Succar and Dawood, 2013) and to collect data confirming the *noteworthiness* of listed BIM publications.

Before introducing a specialized taxonomy to classify and analyse these publications, it is important to first explore the importance of well-structured taxonomies in organizing domain knowledge.

USING TAXONOMIES TO ORGANIZE KNOWLEDGE CONTENT

Taxonomies are an efficient and effective way to consolidate knowledge (Reisman, 2005). A well-structured taxonomy allows "the meaningful clustering of experience" (Kwasnik, 1999 - Page 24) and are "a means toward a number of different ends; one of these ends is providing direction and/or guidance to expansion or generalization of knowledge" (Reisman, 1988 – page 216).

Taxonomies originated in biological sciences (Hedden, 2010) and have been used for organizing knowledge in varied domains. For example, taxonomies have been used to facilitate information interoperability and retrieval (Cheng et al., 2010); define semantic conflicts in business databases (Kashyap and Sheth 1996); organize virtual worlds (Milgram and Kishino, 1996); classify diseases (Burgun and Bodenreider, 2001); and categorize human errors in train accidents (Reinach and Viale, 2006). Also within the construction industry, several taxonomies have been developed to organize domain knowledge. For example, Zuppa and Issa (2008) explored a taxonomy documenting the prioritized interests of stakeholders and aligning their interests; El-Diraby, Lima, and Feis (2005) presented a taxonomy for construction management; Sun and Meng (2008) developed taxonomies covering change causes and change effects in construction projects; Garrett and Teizer (2009) presented a taxonomy-enabled educational system for the classifying and analyzing human errors affecting construction safety; and Wang and Dunston (2011) developed a user centric classification of Mixed Reality (MR) approaches within the construction industry.

As a *knowledge organization system* (Hedden, 2010), taxonomies play an important role in clarifying complex topics and facilitating understanding. The next section introduces a specialized taxonomy that assists in understanding the deliverables of noteworthy BIM publications and comparing their knowledge contents.

THE BIM KNOWLEDGE CONTENT TAXONOMY

There are numerous noteworthy BIM publications covering a large number of overlapping BIM topics. The knowledge contained within these publications may be masked by the document's chosen title and inconsistent use of terminology across different documents. To facilitate access to the knowledge contents across noteworthy BIM publications and enable their comparison and analysis, this chapter introduces the BIM Knowledge Content (BKC) taxonomy. The BKC taxonomy is derived from explicit ontological structures of the BIM Framework (Succar, 2009) (Succar, 2013) as described in Figure 2:

As described in Figure 2, the BIM Knowledge Content taxonomy includes three *knowledge content clusters* – Guides, Protocols and Mandates:

- **Guides**: documents which are *descriptive* and *optional*. Guides clarify goals, report on surveys/accomplishments or simplify complex topics. Guides do not provide detailed steps to follow to attain a goal or complete an activity.

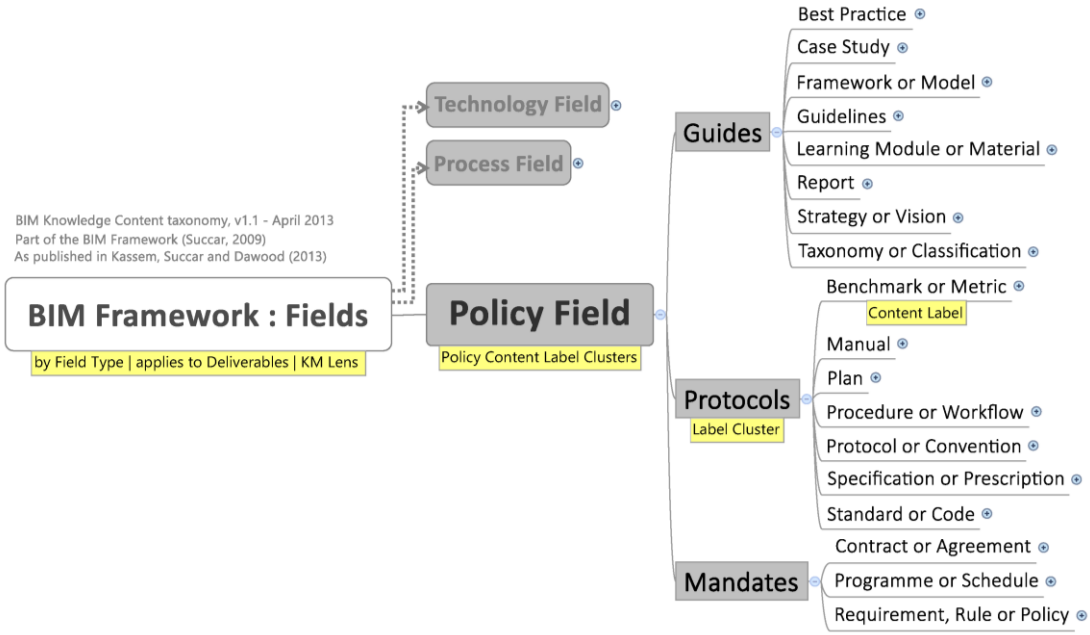

Figure 2. The BIM Knowledge Content taxonomy – Mind Map

- **Protocols**: documents which are *prescriptive* and *optional*. Protocols provide detailed steps or conditions to reach a goal or deliver a measureable outcome. While documents within this cluster are prescriptive, they are optional to follow unless dictated within a Mandate (see next cluster).
- **Mandates**: documents which are *prescriptive* and *dictated* by an authority. Mandates identify *what* should be delivered and – in some cases – *how, when* and *by whom* it should be delivered.

Each of the knowledge content clusters includes a number of *knowledge content labels* to identify and delimit specific knowledge types. Table 2 in the appendix lists the 18 labels and provides a summary of their BIM-specific definitions.

The BKC taxonomy explored in Table 2 includes three content clusters and eighteen content labels. These clusters and labels facilitate the examination of noteworthy BIM publications by "[shifting] the focus of perusal and interaction away from potentially uninformative document surrogates (such as titles, sentence fragments and URLs) to actual document content, and uses this content to drive the information seeking process" (White, Jose and Ruthven, 2005 - page 1). Also, by defining a *common vocabulary* to identify knowledge contents (Holsapple and Joshi, 1999), the BKC taxonomy is able to organize a large extent of disjointed domain knowledge into a structure that is useful, accurate and trustworthy (Forze and Di Nuzzo, 1998).

Analysis of BIM publications using knowledge content taxonomy

The BIM knowledge content taxonomy includes 18 content labels intended to analyze the BIM knowledge contained within publications and other knowledge sources. Ten of these labels have been chosen from across the 3 content clusters

and applied to the 57 noteworthy BIM publications from eight different countries (Table 1). The distribution of these content labels is explored in Table 3 in the appendix.

The 57 noteworthy BIM publications analyzed in Table 3 include a substantial sum of specialized BIM knowledge. However, the coverage and distribution of this BIM knowledge varies significantly across the eight countries. Table 4 shows the quantities and types of BIM knowledge content labels identified within the 57 noteworthy BIM publications from eight countries.

Table 4. A summary of BIM knowledge content labels from the eight countries

	Guides				Protocols				Mandates	
	Case Study	Guideline	Report	Strategy or…	Metric or…	Manual	Procedures or…	Specifications …	Contract or…	Requirement…
	G2	G4	G8	G9	P1	P2	P4	P6	M1	M3
Australia	1	4	3	1	0	2	2	1	0	0
Denmark	0	2	0	1	1	1	0	1	0	1
Finland	0	2	0	1	2	0	0	0	0	2
Norway	1	1	1	1	0	1	0	0	0	1
Singapore	0	0	0	1	0	0	0	0	0	1
The Netherlands	0	1	0	1	1	0	0	2	0	2
United Kingdom	1	2	3	3	4	1	1	0	1	1
United States	3	8	2	1	5	1	4	4	11	5

Using Tables 1, 3 and 4 as a guide, the following paragraphs provide a succinct analysis of the BIM knowledge content available to stakeholders within each country:

Australia

As indicated by surveys and workshops conducted within the last few years, BIM tools and workflows are increasingly being adopted across the Australian construction industry (BEIIC, 2010) (buildingSMART, 2012). These surveys however do not clarify BIM adoption rates across all disciplines or the quality/consistency of BIM deliverables.

Using the Noteworthy BIM Publications as an indicator, NBPs emanating from Australia show an abundance of reports discussing the benefits, risks and challenges of BIM implementation. While many of these publications overlap in arguing the case for model-based workflows and suggesting roadmaps for industry-wide adoption, only a few publications provide implementation steps or detailed protocols for industry practitioners to follow. These represent a handful of seed BIM specifications and procedures (AMCA, 2012) (NATSPEC, 2011) (ANZRS, 2011) which have been developed and highlight significant knowledge

gaps that still need to be addressed. For example, Australia's NBPs do not include a BIM-ready classification system - similar to UniClass2 (UK) and OmniClass Table 21 (US) – which is key for uniform exchanges of model objects, cost information and other metadata.

Tables 3 and 4 also identify a lack in *mandates* – typically developed by governmental units or large client bodies – that define BIM requirements and thus encourage BIM adoption. With the absence of such mandates, industry associations and advocacy groups – not governmental bodies - are still the main players who are "actively driving the development of standards and protocols for the generation and exchange of building information" (CIBER, 2012, page 19).
In summary, the unequal distribution of NBPs across the three *content clusters* highlights a fundamental challenge facing industry stakeholders in Australia: overlapping guides, insufficient protocols and a complete lack of governmental mandates.

Denmark

Denmark is one of the first countries to actively develop BIM guidelines and protocols. Their earliest version of their BIM guidelines called BIPS (BIPS, 2008) was released in 2007. Also, BIM deliverables were partially mandated on public sector projects worth more than DKK 40M ($7M) and architects, engineers and contractors working on government projects were required to use a number of new digital routines, approaches and tools (Kubba, 2012). Additional guidelines for digital collaboration between stakeholders were issued in 2008 (refer to DK 05 in Table 1). A simple analysis of the time each guide and mandate was issued indicates a steady process of developing guidelines and mandating BIM on projects of increasingly smaller value over time. Indeed, in 2010, BIM was mandated on all projects worth more than DKK 20 M ($ 3.5 M), a 50% drop from the previous threshold of DKK 40M ($7M) (refer to DK 06 in Table 1). Moreover, this already low threshold was further decreased following the decision of the Danish Government to mandate BIM on all central government projects worth more than DKK 5M ($ 870K) (Building SMART, 2011b). Also, the Danish Digital Construction initiative (refer to DK 06 in Table 1) specified that stakeholders working on public construction projects should use the following four means: (1) electronic tendering submission system based on a specified bill of quantities and a portal for submitting tenders; (2) a project web environment for participants to share project data and exchange documents, drawings and specifications; (3) 3D models interchangeable in IFC format to be used across all project lifecycle phases; and (4) electronic hand-over of data from the construction project as relevant for facility operation (Det Digitale Byggeri, 2010).

It is important to observe strong BIM leadership in Denmark is stemming from the public sector (i.e. from the Palaces and Properties Agency, Danish University, Property Agency and Defence Construction Service). Also, as early as 2006, 50% of architects and 40% of engineers in Denmark were using BIM in some parts of their projects (Kubka, 2012).

The distribution of NBPs emanating from Denmark provides a clear picture of the country's BIM landscape. NBPs are well-distributed among the three clusters (Guides, Protocols and Mandates). However, the number of legal documents and case studies in Denmark is surprisingly low despite the aggressive digital procurement routes adopted in Denmark since early 2007. Also Table 3

indicates a lack in both BIM workflows to clarify project processes and assessment tools to manage BIM competencies.

Finland

Finland exhibits a considerable commitment to BIM adoption by both the public and private sectors. As evidenced by NBPs listed in Table 1 both public and private entities have been collaboratively involved in conducting BIM pilot projects and developing BIM guidelines since the early 2000s. Also, according to Kiviniemi (2007), BIM surveys conducted in Finland report high BIM adoption rates by architects (93%) and engineers (60%). The Finnish BIM guidelines, based on an R&D project called 'ProIT', were also widely supported by industry (Kubba, 2012). Finally, Senate Properties, the government owned enterprise responsible for managing the property assets of the Finnish state, started requiring BIM/IFC on their projects in October 2007 (Senate, 2007b). Finland is now seeking to replicate the success and acknowledgment gained as an early developer and adopter of BIM in the building sector across the infrastructure sector. Some major research efforts, such as the Infra FINBIM have been initiated with the aim of establishing a systematic shift, into the Finnish infra sector, from to intelligent BIM-based service production that considers the entire life cycle and all sub-areas, actors and functions (INFRA FINBIM work package, 2013).

The distribution of NBPs emanating from Finland (Table 3) indicates several gaps within the protocols and mandates clusters. Multi-volume, discipline-specific BIM guidelines (refer to FE 01 in Table 1) provide an introduction into the fundamentals of product modeling yet do not introduce any data exchange specifications. Also, despite that clients can request the use of BIM for design validation, energy simulation, structural analysis and other analyses, there are no publically-available contractual guidelines that address liability issues, compensation matters and intellectual property rights. Furthermore, there are still no available metrics to assess the BIM capabilities of organizations or documented workflows to assist in streamlining BIM project delivery.

Norway

The Norwegian BIM guidelines called "Statsbygg Building Information modeling Manual – version 1.2" were developed in coordination with the American National Institute of Building Science's NBIMS (National BIM Standard) (Wong et al., 2009). Statsbygg is the Norwegian government's key advisor in construction and its building commissioner, property manager and property developer. Statsbygg conducted several pilot projects using Industry Foundation Classes (IFC)s starting in the early 2000s (refer to NO 01 in Table 1). Following these, BIM guidelines were developed (NO 05) and BIM was mandated on all public sector projects starting from 2010 (NO 02). However, although the demand for BIM is promoted and mandated by the public sector, industry associations have also been active in developing their own BIM manuals. For example, the association of Norwegian Home Builders developed their own BIM manual (refer to NO 04 in Table 1) to provide practical advice associated with BIM processes, modeling and utilization (NHA, 2011).

NBPs emanating from Norway include a higher concentration of *guides* as opposed to *protocols* and *mandates* (refer to Table 3). Among the gaps detected are the absence of metrics or benchmark to facilitate performance assessment/improvement and no defined BIM workflows to assist in structuring

model-based exchanges. Although BIM has been mandated on all projects starting 2010, there are still no contractual documents that address the specific legal and intellectual property issues arising from BIM implementation.

Singapore

Public sector organizations in Singapore such as Building and Construction Authority (BCA) -in collaboration with private entities such as the Construction and Real Estate Network (CORENET) - are taking the lead in adopting and mandating BIM adoption. The BCA, an agency under the Ministry of National Development, delivers many programs to raise awareness including workshops, roadshows and promoting success stories (e.g. ArtScience Museum, Housing projects by the Housing and Development Board) (BuildingSMART, 2011b) . The agency also assists industry stakeholders to build capability and capacity through the BCA Academy that deliver BIM training programs to equip public sector consultants and contractors (Building SMART, 2011b) and a 'BIM Fund' that partially covers the costs for BIM adoption by organizations (Building SMART, 2011b). Finally, the BCA has mandated a phased BIM implementation program: larger projects are required to use BIM for their architectural designs by 2013 and for engineering designs by 2014; and smaller projects, both architectural and engineering designs by 2015 (refer to SG 01 in Table 1).

It is also important to note that Singapore pioneered a BIM-specific 'e-Submission System' (eSS) that supports IFC and allows AEC organizations to submit their project documents over the internet (CORENET eSS, 2009). Singapore also has ambitious goals to increase overall BIM adoption rates to 80% by 2015 - as stated in their BIM roadmap (refer to SG 01 in Table 1) - up from 10% in 2008 and 25% in 2011 (buildingSMART, 2011b).

Analysis of Singaporean's NBPs (refer to Table 3) indicates a holistic and top-down approach to BIM adoption. While labels from all the three clusters exist within the analyzed NBPs, BIM assessment benchmarks for BIM capabilities and competencies are still lacking. This is somewhat unexpected given the on-going BIM training and certification program driven by BCA. Also, with the exception of BIM workflows adopted from Penn State's Computer Integrated Construction (CIC) Research Group (Penn State, 2010), Singapore's BIM guide (refer to SG 02 in Table 1) still lacks well-documented workflows to guide BIM project delivery.

The Netherlands

The Dutch BIM guidelines called "Rgd BIM Standard" (refer to NL03 in Table 1) and the Dutch BIM Strategy (NL 01) has been first issued in 2012. BIM deliverables - through the IFC format – have been mandated on all projects worth more than €10M starting from November 2012. According to Dr. Alex Vermeulen, director of Rgd, A&A, the expectations behind the guidelines and strategy is that models of existing buildings should be delivered using both proprietary and non-proprietary formats (i.e. IFC) and kept live throughout the building's lifecycle (Building SMART, 2011b). The Dutch guidelines also identifies the legal responsibility covering BIM exchanges and adopts levels of development (LOD)s from the "AIA E202 – 2008 BIM Protocol Exhibit" as a basic measure to identify model-based deliverables. Also, the Dutch guidelines employ 'BIM Quick Scan' (refer to NL 01 in Table 1), a benchmarking tool developed by TNO, for assessing the BIM performance of organizations.

Analysis of Dutch NBPs reveals a balanced distribution across the three

content clusters despite the relatively recent release of these publications. This indicates that Dutch BIM policy makers may have benefited from the experiences of other countries. Finally, and similar to other reviewed countries, there are still no documented BIM workflows or procedures to reflect the specific attributes of the Dutch construction industry.

The United Kingdom

The United Kingdom has been active in developing strategies and BIM policies for improving the performance of its construction industry. In May 2011, the UK Government published its "Government Construction Strategy (GSC)" (refer to GB 02 in Table 1) which emphasized the need to develop standards for enabling all members of the supply chain to work collaboratively through BIM. The strategy also announced that the "Government will require fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum by 2016" (refer to GB 06 in Table 1).

A "BIM Task Group" bringing together the expertise from industry, government, public sector, institutes and academia, was formed and tasked to deliver the Government strategy. The first version of the UK BIM guidelines was then developed and released in 2013 (GB 07) and identified three major milestones (called maturity levels) for industry to aim for: Level 1 (2d/3D CAD file based collaboration), Level 2 (BIM file based collaboration), and Level 3 (fully open and integrated web service environment). The Task Group then went on to mandate deliverables to be at Level 2 by 2016. Compared to Singapore which mandated Level 3 UK-equivalent by 2015, the UK strategy seems much less ambitious. However, this phased approach to BIM implementation - recommended by a Strategy Paper to the Government Construction Client Group (refer to GB 04 in Table 1) – actually reflects how most UK firms are still at Level 1.

To support the implementation of BIM Level 2, several NBPs have been lately released. These include 'BS 1192' by the British Standards Institution (BSI) which establishes a methodology for managing the production, distribution and quality of construction information. The British BIM guidelines also contains some contractual guidance covering intellectual property rights and the incorporation of BIM protocols into all direct contracts between the employer and the project team members.

In addition to the publications sponsored/released by the UK government and BSI, industry associations are also playing a significant role in releasing NBPs. For example, the Royal Institute of British Architects (RIBA) has updated their popular RIBA 'Outline Plan of Work' to include a 'BIM Overlay' (RIBA, 2012) reflecting the changes BIM introduces to different project phases.

NBPs emanating from the UK incorporate nearly all knowledge content labels. However, despite the recency of most of these publications, there are many similar deliverables and much duplicated effort (refer to Table 3). Organizational assessment metrics (refer to GB 03 in Table 1) are still elementary and not based on grounded research. Also, with the exception of workflows showing 'data-drop stages for COBie'[4] there are still limited documented workflows which clarify BIM implementation or collaboration procedures.

[4] For an example, please refer to http://www.bimtaskgroup.org/wp-content/uploads/2012/03/COBie-data-drops-29.03.12.pdf, last visited April 29, 2013

United States

The United States is the most prolific producer of noteworthy BIM publications. This is primarily driven by the numerous industry bodies (e.g. AGC, AIA and NIBS), governmental agencies (e.g. GSA, USACE, USCG, and NIST) and local authorities (e.g. NYCDDC and OHIO DAS) which have been actively developing their BIM guides and mandating BIM use since 2007. According to McGraw Hill Construction (2012), BIM adoption rates among contractors, architects and engineers in 2012 are at 74%, 70% and 67% respectively.

Many US noteworthy BIM publications, especially those developed by governmental agencies, are addressed to contractors or intended to facilitate the delivery/handover of facilities to operators upon construction completion. NBPs with a more holistic view are those developed by the NIBS (refer to US 04 and US 19 in Table 1) which continue to act as reference documents for other institutions and bodies. For example, the "National Building Information Modeling Standard" (refer to US 19 in Table 1) covers most topics related to BIM implementation and collaboration and includes a BIM capability maturity model for performance assessment.

NBPs emanating from the US are well distributed across all three content clusters - guides, protocols and mandates. Some of these NBPs are very similar and represent a partial duplication of effort among industry bodies (e.g. between US 02, US 06 and US 07 in Table 3) and among local authorities (e.g. between US 07 and US 16 in Table 3). Another significant characteristic of US NBPs is the availability of workflows and procedures covering all project lifecycle phases (e.g. US 09 and US 10). Also, US NBPs include an abundance of mandates (e.g. contractual templates and procurement requirements) (Table 4) developed by governmental agencies and large client bodies. These mandates represent a clear indication of the leading roles these bodies play in shaping and driving industry-wide BIM adoption. This is reflected by the extensive effort undertaken to develop a set of information exchange specifications (e.g. US20 in table 1) covering all disciplines and facilitating data capture throughout a facility's lifecycle.

COMPARISON OF BIM KNOWLEDGE CONTENT ACROSS COUNTRIES

The BIM knowledge content (BKC) taxonomy is used to analyze noteworthy BIM publication (NBP)s across eight countries selected for their active BIM scene. This taxonomic approach allows comparisons to be drawn between different publications and between different countries. As a tiered classification, the three label clusters with their distinct properties (*guides* are descriptive and optional; *protocols* are prescriptive and optional; and *mandates* are prescriptive and dictated) - provide an insight into the BIM scene of each country. Some countries have a balanced distribution between clusters (e.g. Singapore and the US) while others have an unbalanced distribution and even lack knowledge contents within a specific cluster (e.g. Australia).

Figures 3 and 4 provide a preliminary visual analysis of the number, percentage and distribution of content labels across the noteworthy BIM publications of the eight selected countries. Figure 3 highlights the large number

of publications emanating from the US and the UK by collating the number of BIM knowledge content labels.

Figure 3 highlights the leading position the US occupies with respect to generating the largest number of NBPs across all three clusters. It also specifically highlights the large number of mandates emanating from the US as compared to all other surveyed countries.

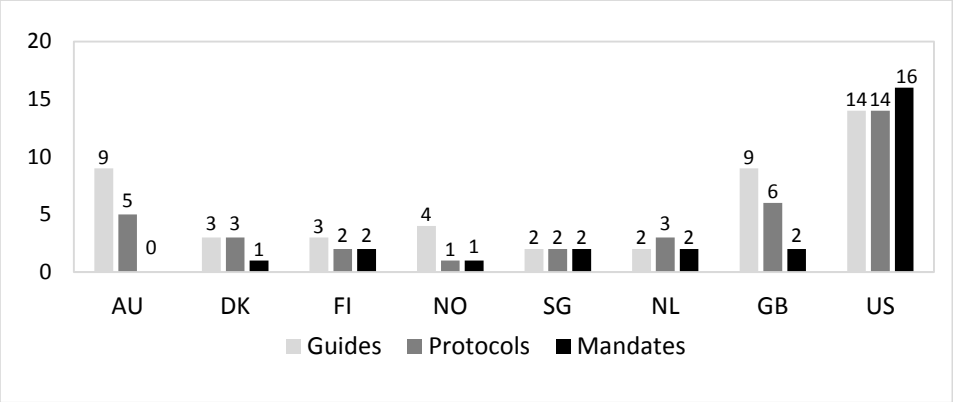

Figure 3. Distribution of guides, protocols and mandates within countries

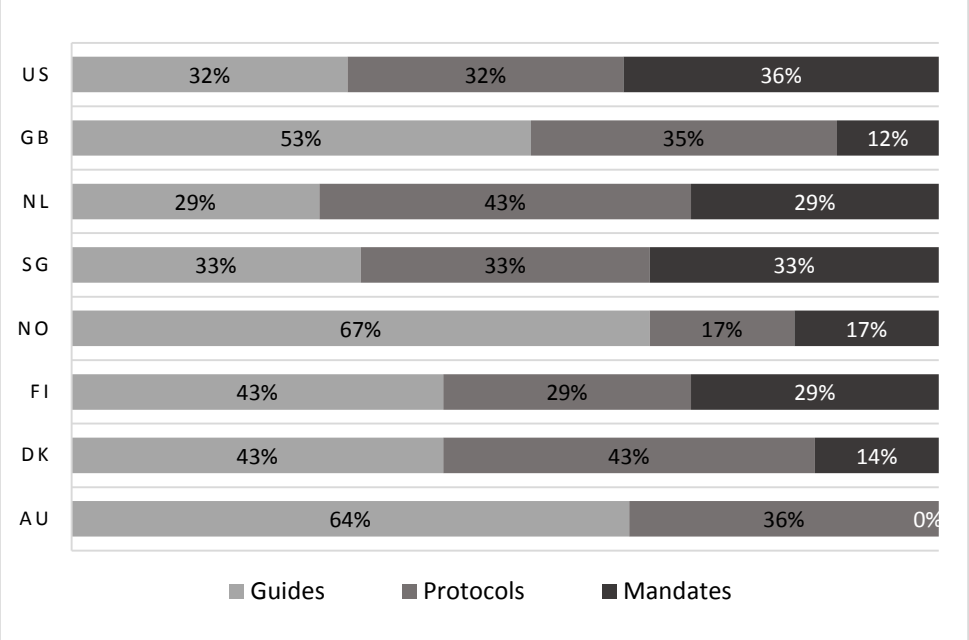

Figure 4. Relative distribution and comparison of guides, protocols and mandates across and within countries

Figure 3 highlights the leading position the US occupies with respect to generating the largest number of NBPs across all three clusters. It also specifically highlights the large number of mandates emanating from the US as compared to all other surveyed countries.

Figure 4 highlights the relative distribution of NBPs across the three labels. It also highlights the difference between a balanced distributions (e.g. that of Singapore) and an unbalanced distribution across clusters (e.g. that of Australia).

The two charts (Figures 3 and 4) are a preliminary representation of how the BKC taxonomy can be used to analyze and compare the knowledge

deliverables of different countries. While such an analysis would not reflect the *quality* of information contained within NBPs, it would facilitate their respective inspection. These charts allow a better understanding of the BIM capability/maturity of countries or even markets, a larger organizational unit within the 12-scale organizational hierarchy (Succar, 2010). Establishing the availability/non-availability of BKC labels across multiple country-specific publications is arguably a good indicator of a country's BIM maturity.

Due to ongoing investigations to confirm the selection/labelling of NBPs, this chapter will avoid an in-depth analysis of data distribution within the preliminary charts. Once data collection is complete, a separate article will provide a more definitive picture of the availability/distribution of knowledge content across different countries.

CONCLUDING NOTES

Noteworthy BIM publications encapsulate a significant volume of domain knowledge. By organizing the knowledge content across these publications, industry-wide comparative analysis and knowledge gap identification can be achieved.

This book chapter introduced a BIM knowledge content taxonomy derived from a published BIM Framework (Succar 2009) (Succar 2013). The BIM content taxonomy consists of a hierarchical cluster of 18 content labels grouped under three content clusters with specific taxonomic properties. The BIM content taxonomy can be utilized in two main ways: organize BIM domain knowledge, and enable targeted access to specific content within numerous publications.

In addition to organizing knowledge within NBPs, the BKC taxonomy provides the traditional functions of indexing support and retrieval support (Hedden 2010). The BKC facilitates indexing support through its controlled vocabulary which allows indexers to classify documents in a consistent manner. Without a controlled vocabulary, multiple documents with the same content may erroneously carry different headings. Indexers may also inadvertently use synonyms for classifying similar documents (Hedden 2010, p. 15).

Retrieval support is a direct consequence of indexing support (Hedden 2010, p. 22) and refers to the ability of a classification to facilitate searching and improve find-ability within databases. The BKC taxonomy can be readily transformed into a facetted classification with its labels (a content type facet) augmented with additional facets – e.g. a content format facet, content relevance facet or issuer type facet (Succar 2013) (Kassem et al. 2013). The BKC can thus support both information retrieval and the faceted analysis (Kwasnik 1999) of noteworthy BIM publications by "[shifting] the focus of perusal and interaction away from potentially uninformative document surrogates (such as titles, sentence fragments and URLs) to actual document content, and uses this content to drive the information seeking process" (White et al. 2005 - page 1).

Organizing BIM domain knowledge allows policy makers and field researchers to identify gaps in their country's BIM policies and to highlight areas which require further research and development. Policy makers can also adopt or

adapt compatible BIM content types from other countries and thus reduce duplication of efforts. Also, the BKC taxonomy can be used to facilitate access to knowledge spread across a large number of publications. Analysis and comparison can be continuously extended to include new publications or to generate more granular labels which pinpoint specific knowledge types.

In this chapter, ten content labels from the BIM knowledge content taxonomy were used to classify 57 noteworthy BIM publications from eight countries selected for their active BIM scene. Analysis of content availability and their distribution provided a structured insight into much published BIM knowledge. Future studies will aim to expand the BIM content taxonomy by considering more granular labels. An online database-driven, web-based prototype will also be developed to further organize domain knowledge and allow extended research findings to be efficiently maintained, managed, and accessed (Zuppa and Issa 2008). Noteworthy BIM publications from additional countries will also be analyzed and compared to provide a wider and more structured understanding of available BIM knowledge content, decrease effort duplication across the wider industry and facilitate BIM adoption.

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APPENDIX

Table 1. A preliminary list and an indicative summary of noteworthy BIM publications from eight countries

Code	Document title	Summary Description	Issuer Type	Reference
AU 01	CRC-CI National Guidelines for Digital Modelling + Case Studies (2 documents)	The guidelines document provides an overview of BIM and how it affects current mode of working. It also provides detailed information about model creation/maintenance, modeling procedures and how to initiate large scale BIM projects. The case studies document includes the lessons learned from implementing BIM in six Australian building projects	Research body	CRC-CI 2009
AU 02	Digital modelling and the built environment, department of Innovation Industry, Science and Research	This report discusses in general terms the benefits and challenges of BIM implementation, and summarizes some of the efforts undertaken both in Australia and overseas	Governmental department	DIISR 2010
AU 03	Productivity in the buildings network: assessing the impacts of Building Information Models, report to the Built Environment Innovation and Industry Council	This report highlights the economic case for BIM adoption in Australia and suggests a road map for BIM adoption. It includes a discussion about BIM benefits, costs, challenges and opportunities and the results from a survey conducted across the sector	Industry body or association *(based on the work of a consultancy firm)*	BEIIC 2010
AU 04	NATSPEC National BIM Guide and Project BIM Brief template	The guide provides a summary description of roles and responsibilities, provides guidance on standards and procurement practices and	Industry body or association	NATSPEC 2011

		introduces a BIM Management Plan template. The template is also intended for guidance and is intended to assist project participants to decide what information to be included within models at different project stages		
AU 05	BuildingSMART Australasia, National Building Information Modelling Initiative	This document discusses benefits and challenges of BIM adoption and surveys international efforts. It's main deliverable is the identification of six interdependent initiatives for government and industry to undertake: procurement, guidelines, education, product libraries, process/data exchange and regulatory frameworks	Industry body or association	buildingSMART 2012
AU 06	BIM in Practice, an initiative by the Australian Institute of Architects and Consult Australia	The initiative includes seventeen complementary papers focusing on four topics: Legal (4), Industry Outreach (7), Education (3) and BIM Management Plans (3). The papers are exploratory and include summary information intended to inform practitioners and generate discussion within industry	Industry body or association	AIA-CA 2012
AU 07	BIM-MEP AUS initiative by the Air Conditioning and Mechanical Contractors' Association of Australia (AMCA)	While focusing on mechanical subcontractors (the associations' members), this industry initiative engages widely with other industry stakeholders and delivers a set of practice guidelines, training material, certified equipment models and software extensions	Industry body or association	AMCA 2012a
DK 01	BIPS C101: CAD Manual	Outlines guidelines for CAD production and collaboration for the Danish construction industry. This fifth revision replaces "C202: CAD Manual 2005" and "3D CAD Manual 2006, Digital Construction"	Industry body or association	BIPS 2008
DK 02	BIPS C202: CAD Manual 2008, basic	Contains guidelines and conceptual descriptions which are applicable across	Industry body or association	BIPS 2008

	description	all types of companies and projects		
DK 03	BIPS F103: Object Structure 2008 - June 2008	Specifies uses and data properties pertaining to construction objects (36 objects)at a given level of detail	Industry body or association	BIPS 2008
DK 04	BIPS F102: Building ICT specifications , instructions - June 2008	Part 1 (see DE 05 for part 2) defines the digital services (BIM deliverables) at different construction project phases and their requirements	Industry body or association	BIPS 2008
DK 05	BIPS F202: ICT output specification, basic description - June 2008	Part 2 explains technical and practical aspects of digital collaboration between construction project parties	Industry body or association	BIPS 2008
DK 06	Digital Construction: A Danish government initiative, English introduction, 2010	This strategy document aims to increase information and knowledge sharing between all AEC's actors and improve project efficiency across all phases through the use of BIM tools and workflows	Industry body or association	Det Digitale Byggeri 2010
FI 01	Senate Properties' Building Information Model Requirements 2007	This document describes general operational procedures to be used in BIM projects with a focus on the design stage. The document is in 9 volumes organized by discipline: 1: General part 2: Modeling of the starting situation 3: Architectural design 4: MEP design 5: Structural design 6: Quality assurance, model merging 7: Quantity take-off 8: Visualization purposes 9: MEP analyses	Government-owned enterprise	Senate 2007a
FI 02	Senate Properties: BIM Requirements 2007 Volume 1: General part	This is an introductory document to the Finnish BIM guidelines (see FI 03 and FI 04) and includes the general objectives for the generation and utilization of models at different project stages. This document also mandates some BIM uses from October 2007.	Government-owned enterprise	Senate 2007b

FI 03	Common BIM Requirements COBIM 2012 v1.0"	Updates the "Senate Properties' Building Information Model Requirements 2007" (FI 01) by adding the following new four series: 10: Energy analysis 11: Management of a BIM project 12: Use of models in facility management 13: Use of models in construction	Government-owned enterprise	Senate 2012
NL 01	Public sector demand for BIM	Mandates BIM and the use of IFCon public projects worth more than €10M starting Nov 2011	Governmental department	GBA in Building SMART 2011a
NL 02	BIM Quickscan: Benchmark of BIM Performance in The Netherlands	An approach for assessing and benchmarking the BIM performance of companies within the Netherlands	Research body	Berlo et al. 2012
NL 03	Rgd BIM Standard, Version 1.0.1, July 2012	Guidelines for design and collaboration within BIM environment. The document describes delivery requirements and specifications of BIM extracts (i.e. IFC model, CAD drawings, measurement data, calculations, and quantity take-offs). It also adopts the AIA E202 – 2008 BIM Protocol Exhibit(Levels of Development from the US)	Governmental department	GBA 2013
N0 01	The HITOS project – a full scale IFC test	A 'full-scale IFC test' documenting experiences gained from a large collaborative BIM project	Industry body or association	Le et al. 2006
NO 02	Statsbygg goes for BIM	To mandate BIM and the use of IFCs on all public construction projects starting 2010	Governmental department	Statsbygg 2007
NO 03	Construction cost program: Reducing barriers - Report from interview – qualitative (in Norwegian)	A report investigating barriers to BIM collaboration. It discusses efficient construction processes and suggests measures to remove or lower adoption barriers	Government – industry partnership	Byggekostnader 2010

NO 04	Norwegian Home Builders' BIM Manual (ver1)	A manual for Norwegian Home Builders providing practical advice covering BIM processes and utilization	Industry body or association	NHA 2011
NO 05	Statsbygg Building Information Modelling Manual, Version 1.2 (SBM1.2)	Describes BIM requirements with a focus on Industry Foundation Classes (IFC)s	Governmental department	Statsbygg 2011
SG 01	All set for the 2015	This document presents Singapore strategy to achieve 80% BIM uptake by 2015 and improve the industry's productivity by up to 25% over the next decade. It also aims to mandate BIM in a phased way: larger projects are required to use BIM for their architectural designs by 2013 and for engineering designs by 2014; smaller projects, both architectural and engineering designs, by 2015	Governmental department	BCA: in BuildSMART 2011
SG 02	Singapore BIM Guide (ver 1.0)	This document provides guidelines for mono-discipline modeling and multidisciplinary collaboration; describes BIM deliverables of various project members at different project stages and their levels of detail; defines a basic BIM workflow for Design-Bid-Build projects; and offers general guidance on risk allocation, compensation and intellectual property rights	Governmental agency	BCA 2012
GB 01	Refurbishment resource efficiency case study: Manchester Central Library	A case study demonstrating the benefits of BIM achieved on a $ 61M refurbishment project	Industry body or association	WRAP 2010
GB 02	Government Construction Strategy	This document includes the UK government strategy aimed to challenge current industry business models and practices and replace them with collaborative supply chain models. This document	Governmental department	Cabinet 2011

		specifies that BIM is a main enabler of this integration and announces the intention of the government to develop 'standards' that enable all members of the supply chain to work collaboratively		
GB 03	CPIx BIM assessment form	A basic form to assess the BIM capabilities of organizations	Industry body or association	CPC 2011
GB 04	BIM Management for value, cost & carbon improvement, report number URN 11/948 - A report for the Government Construction Client	This document outlines four BIM maturity levels (0, 1, 2 and 3) intended to categorize technical and collaborative working types and describe processes, tools and techniques to be used. It also includes workflows that clarify data exchange requirements at specific project milestones It outlines a strategy to increase the BIM adoption over a five year period as part of a wider government strategy aimed to improve construction value and carbon performance and decrease cost	Governmental department	DBIS 2011
GB 05	AEC (UK) BIM Protocol Implementing UK BIM Standards for the Architectural, Engineering and Construction industry - Updated to unify protocols outlined in AEC (UK) BIM Standard for Revit and Bentley Building Version 2.0 September 2012	This document includes guidelines, specific to Revit, Bentley, ArchiCAD and Vectorworks which can be used to inform the creation of BIM elements and facilitate BIM collaboration. It also introduces modeling 'Grades', a system similar to AIA's Levels of Development (LOD)s	Community of Practice	AEC 2012
GB 06	Soft Landing Strategy	This document aims to align the interests of facility designers and construction	Governmental department	Cabinet Office 2012

		companies with those of facility owners and operators. It also introduces a mandate for BIM by 2016 for all Central Government Department projects		
GB 07	Building Information Model (BIM) Protocol - Standard Protocol for use in projects using Building Information Models, CIC/BIM ProFirst Edition 2013	Guides that identify model-based requirements to be produced project team members: their obligations, liabilities and associated limitations It also includes several intellectual property rights' clauses clarifying permitted uses of models, levels of development and other contractual requirements	Industry body or association	CIC 2013
GB 08	National BIM Report 2013	A report providing insight and opinions of UK industry leaders. It includes survey results describing levels of BIM uptake	Private industry	NBS 2013
GB 09	Building Information Modelling - an introduction for house builders	A manual explaining basic BIM concepts to UK house builders. It includes survey results describing levels of BIM uptake	Industry body or association	NHBC Foundation 2013
GB 10	First Steps to BIM March 2013 Competence A Guide for Specialist Contractors	A report to contractors explaining the BIM fundamentals, business benefits, how to get started with BIM, legal implications, roles and responsibilities	Industry body or association	NSCC 2013
US 01	BIM user guides	This document presents guidelines to develop and maintain a BIM standard	Governmental department	USCG 2005
US 02	Contractor's Guide to BIM	This document provides basic guidelines for contractors who intend start using BIM. It also discusses the impact of BIM on responsibilities and liabilities and indicated the areas of risk management for contractors	Industry body or association	AGC 2006b
US 03	Consensus Docs 301 BIM Addendum	This document globally addresses legal and administration issues associated with the use of BIM	Industry body or association	ACGA 2006
US	NISTIR 7259	This document has two parts.	Governmental	NIST and

04	Capital Facilities Information Handover Guide, Part 1	Part 1 presents a methodology for defining the information requirements for the full facility life cycle and then develops and implements an information handover plan for a specific capital facility project. Part 2 describes describe case studies, specific standards and data forms applicable to different capital facility types, e.g., general building, process plant and transportation infrastructure.	department / Community of practice	FIATECH 2006
US 05	Building Information Modeling: A Road Map for Implementation To Support MILCON Transformation and Civil Works Projects within the U.S. Army Corps of Engineers	A document outlining the organizational and process change needed to effectively integrate BIM into in-house and A/E designs on USACE project world-wide.	Governmental department	USACE 2006
US 06	Integrated project delivery: a guide	This document includes guidelines for integrating people, systems, business structures and practices into a project to increase value to the owner, reduce waste, and maximize efficiency through all project phases. It also addresses issues related to multi-party agreements such as risk and reward, liability and dispute resolution	Industry body or association	AIA 2007
US 07	GSA BIM guides series	This document includes general guidelines for GSA associates and consultants engaged in 3D and 4D activities. It also contains a section covering data ownership rights	Governmental department	GSA 2007
US 08	State of Ohio Building Information Modeling protocol	A document presenting the BIM requirements related to: requests for qualifications, agreements, bidding and contracts, list of deliverables/BIM services, and information exchange It also addresses	Local authority	OHIO DAS 2010

		compensation expectations and level of development of the BIM model at for different project element		
US 09	BIM Project Execution Planning Guide and Templates – Version 2.0 BIM Project Execution Planning	This document presents guidelines to help the identification of BIM goals and uses and contains process maps and template resources for the the implementation of different BIM uses	Research body	Penn State 2010
US 10	Building Information Modeling (BIM) Roadmap Supplement 2 – BIM Implementation Plan for Military Construction Projects, Bentley Platform	This document includes workflows that are specific to Bentley platform users working for USACE. It describes the workflows for site analysis, space programming, architectural design, etc., and presents interoperability requirements and training opportunities	Governmental department	USACE 2011
US 11	E203: Building Information Modeling and Data Exhibit	A document defining the levels of development (LoD), the authorized uses of BIM on projects and the responsibility for the defined LOD(s) at each project phase	Industry body or association	AIA 2012a
US 12	G Document 201: Project Digital Data Protocol Form	A document that includes a contractual form to document the 'digital data protocols' agreed upon by project stakeholders	Industry body or association	AIA 2012b
US 13	G Document 202: Building Information Modeling Form	A document that includes a contractual to document the 'BIM protocols' agreed upon by project stakeholders	Industry body or association	AIA 2012c
US 14	IPD Case Studies	This report compares twelve IPD projects - ten of which has used BIM -in terms of contractual and behavioral strategies. It also includes the results of a survey regarding IPD contractual principles and collaborative project delivery methods	Industry body or association / Research body	AIA and University of Minnesota 2012
US 15	The Business value of BIM in North America:	This document consists of a report presenting the adoption rates and the uses of BIM in the U.S. and	Private industry	McGraw-Hill Construction 2012

	Multi-Year Trend Analysis and User Ratings (2007-2012)	summarizing the results and benefits obtained from five case studies		
US 16	BIM guidelines	This document includes requirements for BIM uses/services, submission and design development. It also specifies the ownership of the model including all inventions, ideas, designs, and methods contained within it	Local authority	NYCDDC 2012
US 17	Planning Guide for Facility Owners– Version 1.0	This documents present guidelines for the integration of BIM throughout the lifecycle of facilities and in Owners' organizations. It also contains contractual requirements for owners.	Research body	Penn State 2012
US 18	USACE BIM Minimum Modeling Matrix (M3) V1.0	This document includes a matrix of modeling requirements for BIM deliverables to ensure the relevance of deliverables to all project stages and to the owner and facility manager	Governmental department	USACE 2012
US 19	National BIM standard – United States™ Version 2	This document superseded NBIMS-US V1 (2007) and is aimed at software developers and practitioners. For software developers, there is an array of reference standards (ISO 16739, IFc 2x3, OmniClass™ tables), model view definitions and information exchange standards. To this version 2, COBie (Construction Operations Building Information Exchange – Version 2.26) was added as the new standard for life-cycle information exchange format describing the spaces and equipment within a facility. For practitioners, there are process execution protocols, 'BIM Minimum' concept for quantity and quality of BIM information and the Capability Maturity Model (CMM) for the evaluation of the BIM	Industry body or association	NIBS 2013

		capability of business practices.		
US 20	Information Exchange Projects	This document summarizes a number of information exchange projects (e.g. BIM Service interface exchange (BIMSie), Building Automation Modeling information exchange (BAMie), Building Programming information exchange (BPie), Construction Operations Building information exchange (COBie), Electrical System information exchange (Sparkie), HVAC information exchange (HVACie), Life Cycle information exchange (LCie), Quantity Takeoff information exchange (QTie), Specifiers' Properties information exchange (SPie), Wall information exchange (WALLie) and Water System information exchange (WSie)) presenting information exchange specification and aimed to enable the capture of BIM over the lifecycle.	Governmental department	USACE 2013
US 21	The COBie Guide: a commentary to the NBIMS-US COBie standard	a Guide identifying general requirements of COBie (Construction Operations Building Information Exchange) deliverables for design and construction contracts. It also includes client and owner's specific requirements	Governmental department	East and Carrasquillo-Mangual 2013

Table 2. BIM Knowledge Content taxonomy (v1.3): 18 content labels in three content clusters

Content CLUSTER	Label CODE	Content LABEL	Label DEFINITION - BIM specific
Guides	G1	Best Practice	Operational methods arising from experience; promoted as advantageous; and replicable by other individuals, organizations and teams. This *label* applies to publications which list unambiguous and detailed recommendations, and which if applied as recommended, generate similar advantageous outcomes
	G2	Case Study	Summary and analysis (descriptive or explanatory) of projects and organizational efforts. This *label* applies to both research and industry publications which share lessons learned *by others,* and cover BIM deliverables, workflows, requirements, challenges and opportunities
	G3	Framework or Model	Theoretical structures explaining or simplifying complex aspects of the BIM domain by identifying meaningful concepts and their relationships
	G4	Guideline	Compilation of several BIM content types with the aim of providing guidance to individuals, teams or organizations. Guides typically provide insight into a complex topic (e.g. BIM Implementation Guide or Facility Handover Guide). Guides typically focus on knowledge-intensive topics, while Manuals (a complementary label) focus on skill-intensive ones. Due to the generic nature of this *label*, it should not be applied in isolation but in conjunction with other labels
	G5	Learning Module or Material	All types of analogue and digital media (e.g. printed manual or online videos) which deliver conceptual or practical insight intended/suitable for education, training or professional development within industry or academia
	G6	Report	Compilation or summary of results arising from an assessment, calculation or review process (e.g. BIM capability report or profitability statement)
	G7	Strategy or Vision	Articulation of vision, mission and long-term goals. This *label* applies to publications which identify a long-term strategy (and possibly middle-term goals/milestones) but without identifying the resources required and detailed steps needed to fulfill the strategy
	G8	Taxonomy or Classification	Classification covering roles, types, levels, elements and other structured concepts. This *label* applies to publications which introduce classifications of five or more items within a

			structured list; and which have a clear use in assessment, learning or implementation (e.g. construction elements, BIM roles, data exchange types or levels of detail)
Protocols	P1	Metric or Benchmark	Tools and criteria suitable for establishing levels of performance of systems, projects, individuals, teams, organizations and other organizational units[5]. This *label* applies to publications which include tools or explicit metrics/indicators for establishing usability, profitability, productivity, competency, capability or similar
	P2	Manual	A structured document which is intended to clarify the steps needed to perform a measureable activity or deliver a measureable outcome (e.g. BIM Training Manual). Manuals typically focus on skill-intensive topics, while Guides (a complementary label) typically focus on skill-intensive ones. Due to the generic nature of this *label*, it should not be applied in isolation but in conjunction with other labels
	P3	Plan	A document describing activities to be performed, resources to be used and milestones to be reached within a defined timeframe. This *label* applies to publications describing – in adequate detail - how a specific strategy can be fulfilled or a pre-defined goal can be reached (e.g. a BIM Implementation Plan detailing how to fulfill a BIM Capability Strategy)
	P4	Procedure or workflow	Structured information covering successive steps needed to fulfill an operational, rather than strategic, requirement. A documented Procedure includes the small steps needed to deliver, if executed by a competent individual, a pre-defined and desired outcome. A Workflow identifies major successive activities to be performed and decision gates to pass-through towards reaching a delivery milestone or fulfilling a project/organizational objective
	P5	Protocol or Convention	Agreed or customary method of product/service development or delivery which are not *by themselves* contractually binding (e.g. keeping minutes of meetings, how to name files and frequency of exchanging models)
	P6	Specification or Prescription	A set of criteria used to define or judge the quality of products (e.g. object dimensions or data richness) and services (e.g. timeliness). Specifications may or may not be a Standard (a separate label). COBie is an example of BIM-related specifications which may become a service/delivery standard over time
	P7	Standard or Code	Detailed set of product/service descriptions (prescriptive or performance-based) acting as a

[5] There are 12 organizational units, each with their own unique metrics (refer to Building Information Modelling Maturity Matrix (Succar, 2010).

			reference to be measured against. This label typically denotes a set of specifications (a separate label) which are authoritative and test-proven (e.g. barrier-free or accessibility standards)
Mandates	M1	Contract or Agreement	Legally-binding document and its subparts – including contractual additions, amendments and disclaimers. This *label* applies to contracts and clauses, not to publications describing or promoting them (e.g. the label applies to AIA Documents E203, G201 and G202 but not to the AIA IPD guide)
	M2	Program or Schedule	A document associating one or more classification to time and/or location. For example, a BIM competency improvement program is a document linking BIM competencies, BIM roles (and possibly other classifications) to a timeline or target dates
	M3	Requirement, Rule or Policy	Expectation or qualification mandated by clients, regulatory authorities or similar parties. This *label* applies to publications with explicit identification of requirements to be met (e.g. organizational capability or previous experience) or products/services to be delivered (e.g. a tender/bid document)

Table 3. An exploration of 55 NBPs from 8 countries using the BKC taxonomy

		Guides				Protocols				Mandates	
		Case Study	Guideline	Report	Strategy or…	Metric or…	Manual	Procedures or…	Specifications …	Contract or…	Requirement …
		G2	G4	G8	G9	P1	P2	P4	P6	M1	M3
Australia	AU 01	●	●				●				
	AU 02			●							
	AU 03			●							
	AU 04		●					●			
	AU 05			●	●						
	AU 06		●								
	AU		●				●	●	●		

		Guides				Protocols				Mandates	
		Case Study G2	Guideline G4	Report G8	Strategy or… G9	Metric or… P1	Manual P2	Procedures or… P4	Specifications … P6	Contract or… M1	Requirement … M3
	07										
Denmark	DK 01		●								
	DK 02		●								
	DK 03					●			●		
	DK 04										●
	DK 05						●				
	DK 06				●						
Finland	FI 01		●			●					●
	FI 02				●						
	FI 03		●			●					●
Norway	NO 01	●									
	NO 02				●						
	NO 03			●							
	NO 04						●				
	NO 05		●								●
Singapore	SG 01				●						●
	SG 02		●			●		●		●	
The Netherlands	NL 01				●						
	NL 02					●					
	NL 03		●						●		●
United Kingdom	GB 01	●									
	GB 02		●			●					
	GB 03					●					
	GB 04			●	●	●		●			
	GB 05				●						
	GB 06				●						●
	GB 07		●			●				●	
	GB 08			●							
	GB 09						●				
	GB 10			●							
United States	US 01		●							`	
	US 02		●							●	
	US 03									●	

	Guides				Protocols				Mandates	
	Case Study G2	Guideline G4	Report G8	Strategy or… G9	Metric or… P1	Manual P2	Procedures or… P4	Specifications … P6	Contract or… M1	Requirement … M3
US 04	●						●	●		●
US 05		●		●						●
US 06		●							●	
US 07		●							●	
US 08					●				●	●
US 09		●					●			
US 10						●	●			
US 11					●				●	
US 12									●	
US 13									●	
US 14	●		●							
US 15	●		●							
US 16					●				●	●
US 17		●								●
US 18					●					
US 19		●		●	●		●	●		
US 20								●		
US 21								●		●